Spawning biology of tor mahseer, *Tor tor* (Ham.)[1]

S. K. Chaturvedi[2]

(*With four text-figures*)

Mahseers, the large-scaled Indian Carps, well known as excellent sport fish as well as food fish, have engaged the attention of naturalists, anglers and biologists from very early times. Their breeding habits have been a matter of much debate and the spawning of different types of Mahssers from various places having different climatic conditions has been studied. Nevertheless, nothing has been known about the Mahseers of Rajasthan where the ecological conditions are much different. Large Mahseers, *Tor tor* (Ham.) and *Tor khudree* (Sykes) abound in the lakes and rivers of southern and eastern Rajasthan forming an important fishery in some of the lakes. David (1953) and recently Kulkarni (1970) highlighted the value of Mahseers in pisciculture and in the recent years Mahseers have been transplanted in other parts of the State. Therefore, in view of the increased attention being paid to the development of the Mahseer stocks in Rajasthan, it was felt imperative to study their spawning habits in this area. The present paper deals with various aspects of the spawning biology of *Tor tor* (Ham.).

Materials and methods

The preliminary observations were started in 1964, but bulk of the material for this study was collected by cast and gill nets during the period August 1968 to June 1972 from Udaipur lakes and connected streams, already described by Dhawan (1969). The measurements of length, weight, observations on sex, weight and extent of gonads in the body cavity, stage of maturity etc. were taken from fresh specimens. To determine fecundity and ova diameter frequencies, the ovaries were preserved in Simpson's (1951) modification of Gilson's fluid.

Test measurements of ova from different parts of the ovary revealed that the progression of ova development throughout the ovary was not differential and ova were found evenly distributed throughout the ovary. However, to obviate any possibility of error egg samples were taken from different regions of both the ovaries. Randomized samples of 500 ova from each mature ovary were studied for ova diameter frequencies by the method followed by Clark (1934) and Prabhu (1956) using an ocular micrometer (1 m.d. = 0.043 mm). Immature ova smaller than 5 m.d. were not taken into account for this purpose.

For fecundity studies a small sample of 1.0 gm was taken, ova teased out of the follicles and counts were made of all ova comprising the mature group. The fecundity was estimated by multiplying the ova count per gram of

[1] Accepted May 1974.

[2] Deputy Director of Fisheries, Rajasthan, Jaipur.

ovary by the total weight of the ovary.

LENGTH-WEIGHT RELATIONSHIP

250 females and 136 males ranging in length from 200-730 mm and 220-750 mm respectively, were measured and weighed. The sex of specimens below 200 mm length could not be reliably determined and hence they were not included in these calculations. The average weight for each 10 mm length interval was taken and the logarithmic values of these

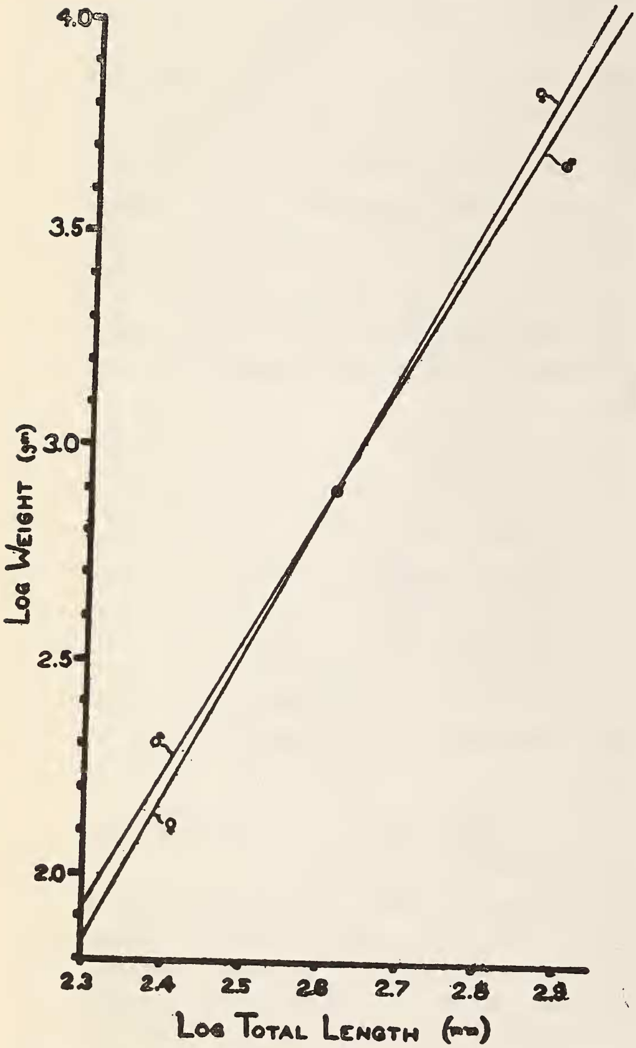

Fig. 1. Logarithmic relation of length and weight of males and females of Tor Mahseer.

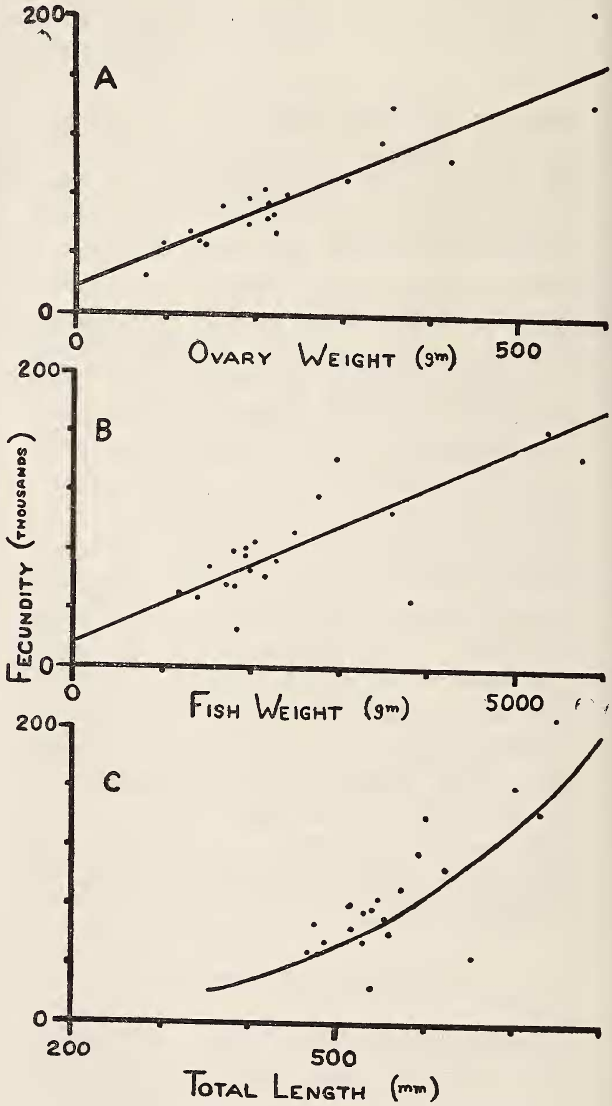

Fig. 2. Fecundity of Tor Mahseer in relation to ovary weight, body weight and total length.

length and weights computed. The length weight relationship was derived by applying the least-spares linear regression formula to the logarithmic transformation of the basic formula $W = aL^b$ (Where W is the weight of fish in grams and L the total length of millimetres for females and males separately. The resulting values can be expressed logarithmically as:

(i) $\text{Log } W = -5.9528 + 3.3927 \text{ Log } L$, for females.

(ii) $\text{Log } W = -5.3477 + 3.1609 \text{ Log } L$, for males.

Fig. 1 depicts the length-weight relationships and Table 1 shows the computed weights of males and females of similar length based on the above equations. It will be observed that length-weight relationship curves for males and females (though not significantly different) intersect at approximately 408 mm in total length, and though the males upto 400 mm were heavier than the females of the same size, the females were heavier amongst fish of larger size. It suggests that somewhere near 400 mm in total length the female overtakes the male in the weight, probably due to the heavier female gonads.

TABLE 1

WEIGHTS OF FEMALES AND MALES OF CORRESPONDING LENGTH

Total length (mm)	Wt. of females (gm)	Wt. of males (gm)
200	71	84
300	283	304
400	750	754
500	1600	1526
600	2970	2716
700	5009	4420
800	7879	6741

SIZE AT FIRST MATURITY

For this purpose the specimens with gonads in the mature stages were observed during the beginning of the spawning season. The smallest mature female was encountered at 322 mm total length. All females below 320 mm size were found immature and most of the females above 390 mm were found mature. Hence it may be stated that the average size at first maturity lies between 320-390 mm. The size at first maturity is rather a constant proportion of the final length attained by a species—Holt (1962). Tor Mahseer is said to attain a maximum length of about 1200 mm Hora (1940) and MacDonald (1948) but in the present investigation the maximum length recorded was 757 mm only. Hence the ratio of the mean length at maturity to the asymptotic length is found to be *c.* 0.5.

The smallest mature male was observed at 254 mm total length and all males above 310 mm were found mature. The males, therefore, appear to mature at a relatively smaller size.

Since an average growth of about 350 mm is attained in one year (as evidenced from stocked fish seed in a nearby tank) it may be stated that both sexes can attain maturity by the end of the first year of their life. This is further confirmed by the fact that the immature fishes did not occur throughout the year. It was also noted that the smaller females which were apparently ready to spawn for the first time matured in the later part of the spawning season. This ensures almost a full year of growth before first spawning.

SEX RATIO

During the period of investigation about 400 adult specimens were sexed by internal examination. Although both the sexes were represented in equal proportions during July-September an overall male: female ratio of 1:1.9 was indicated, i.e. the females greatly exceeded males in number. Table 2 gives the percentage of each sex in different size groups. It could be seen that there were more males than females amongst smaller group, but with the increase in size (and hence age) females become more abundant. Codrington (1946) and MacDonald (1948) made similar observations. Bennet (1962) also noted that this pattern was common in fish populations, presumably due to a higher mortality rate among the males. But this may also be due, in part, to gear selectively on account of girth differences in the two sexes.

Table 2

Percentage of each sex in different size groups

Class range	Females	Males
250-299	15.78	84.22
300-349	41.51	58.49
350-399	37.20	62.80
400-449	46.43	53.57
450-499	73.17	26.83
500-549	80.32	19.68
550-599	85.71	14.29
600-649	87.17	12.83
650-699	100.00	0.0
700-749	90.00	10.00
750-799	100.00	0.0

Sex dimorphism

In the males the pectoral fin extends to the seventh scale below the lateral line, while in females it is shorter, reaching below the fifth or sixth scale of the lateral line. Besides this, in the females the bulkiness of the abdomen gives rise to an arched ventral profile and the base of the anal fin projects out of profile line, whereas in the males the profile is comparatively less arched and the base of the anal fin does not as much project out of the profile line. There appeared to be no difference in the colours of the two sexes, and roughness of the pectorals was not felt even in the ripe males.

Almost similar characters to distinguish sexes in *Tor khudree* have been observed by Kulkarni (1970).

Maturity stages

The gonads are paired, elongated organs suspended one on each side from the dorsal wall of the body cavity. These become progressively enlarged as the fish attain sexual maturity. Accordingly, certain stages have been identified for males and females separately.

(a) *Females*:

On the basis of macroscopic and microscopic examination seven stages of maturity were demarcated, which nearly correspond to those of International scale, Wood (1930). The peculiar features of these seven stages are given below:

I. Immature—

Ovaries small, thin, extending about half the length of the body cavity. Pinkish translucent. Ova not visible to the naked eye; mean ova diameter ranging from 2-4 m.d., with prominent nucleus and no yolk granules. The relative weight to body weight normally below 0.8 per cent.

II. Developing—

Early maturing or recovered spent in resting condition: Ovaries extending more than half the length of the body cavity. Pinkish or flesh coloured. Some ova visible to the naked eye. Few yolk granules present. Mean ova diameter ranging from 4 to 10 m.d.

III. Maturing—

Maturing fish: Ovaries extending about two-third length of the body cavity. Creamy white or yellowish in colour. Ova opaque, mean diameter ranging from 10 to 18 m.d.

IV. Maturing—

Advance maturing fish: Ovaries enlarged, occupying three-fourth length of the body cavity. Yellowish in colour. Ova opaque, larger ova fully yolked; mean ova diameter ranging from 18 to 28 m.d.

V. Mature—

Mature fish, but not running. Ovary extending to the entire length of body cavity. Ova bright yellow, fully yolked, opaque or transluscent, with transparent periphery, mean diameter ranging from 28 to 42 m.d.

VI. Ripe—

Spawning in progress or just imminent; large, free, spherical, more or less transparent ova, lemon yellow in colour: Ova can be extruded on slight pressure; Ovaries may form upto 16 per cent of the body weight.

VII. Spent—

Ovary small, loose and flaccid; reddish in colour, wholly or partly. Few remnants of ripe ova seen in the lumen of ovaries.

(b) *Males*:

On the basis of macroscopic examination, only five stage were identified.

I. Immature—

Testes small, thin pinkish strands extending to about one-third length of body cavity. Form upto 0.5 per cent of the weight of the fish.

II. Developing—

Developing virgin or spent resting: Pinkish translucent or fleshly opaque in colour. Thicker, more elongated, extending to about half the length of body cavity.

III. Maturing—

Testes enlarged, lobed, medium-sized. Pinkish white in colour; extend to about two-third of the length of body cavity.

IV. Mature—

Testes massive in appearance, extending over the entire length of the body cavity. Whitish-pink. Milt oozes out on slight pressure on the abdomen or even while handling. May form upto 9.5 per cent of the body weight.

V. Spent—

Testes shrunken, loose and flabby; extending to more than half of the length of the body cavity.

Fecundity

The fecundity of 23 mature females ranging from 465 mm to 740 mm in total length was estimated. The data are presented in Table 3.

Table 3

Average fecundity estimates at various size ranges

Length Range	Av. length (mm)	Av. Wt. (gm)	Av. Wt. of ovary (gm)	Av. No. of ova	No. of ova Per gm Wt. of fish	No. of ova Per gm. Wt. of ovary
400-500	472	1402	145.5	49,146	35.07	336.6
500-600	546	2155	217	78,340	36.35	361
600-700	655	4220	401	103,882	24.61	259
700-800	732	5950	577.5	175,886	29.56	304.3

The average fecundity ranged from 49,146 to 1,75,886, the number of ova per gram weight of ovary from 259 to 361 and the number of ova per gram weight of fish from 24.61 to 36.35. The following relationships with fecundity were also determined, (F denotes fecundity in thousands of ova) and are shown graphically in Fig. 2.

Fecundity and Ovary Weight:

A least-squares linear regression was used to fit a straight line equation to the relationship between the ovary weight and the fecundity. It showed a high degree of positive correlation ($r = 0.8931$), the relationship being,

$F = 17.66 + 0.2578\ W$

Where W = the ovary weight in grams.

Fecundity and Body Weight:

Least square regressions were carried out on both the observed values for fecundity and fish weight, and on their longarithmic equivalents, the latter to test for an exponential relationship. The equations that resulted are given below:

$F = 15.49 + 0.02637\ W \ (r = 0.802)$

$\text{Log } F = 1.1170 + 0.8858 \log W \ (r = 0.714)$

Where W = the total fish weight in grams.

The application of the z-test (Fisher 1958) showed no significant difference in the correlation coefficients (5% level). Although the sample is relatively small, this suggests that the simple linear relationship is sufficiently accurate. It also has the advantage of being easier to calculate for routine work. The equation for the exponential relationship, however, suggests that the relative fecundity may decrease with increasing fish weight. Additional data are needed to check this possibility.

Fecundity and Total Length:

As the relationship between fecundity and total length of fish was expected to be exponential, a least-squares regression on the logarithmic values was carried out. The equation for the resultant line, given below show a fairly high degree of correlation ($r = 0.666$)

$\text{Log } F = -5.6527 + 2.7381\ L.$

Where L = total length of fish in mm.

Spawning Periodicity

Many workers, Clark (1934), Hickling & Rutenberg (1936), Prabhu (1956), Qasim & Qayyum (1961), have determined the spawning periodicities of fishes by the studies of ova diameter frequency distributions from ovaries in the ripe or penultimate stage of the ovaries. The frequency distribution of the intra-ovarian eggs from 32 mature Mahseers was, therefore, studied. Since separate polygons drawn from individual fishes, even of different years, showed no difference in the pattern of ova diameter frequencies, no variation in the spawning periodicity between individuals was indicated. Hence the pooled frequency distribution of the intra-ovarian eggs have been depicted in Fig. 3 with the diameters divided into 5 m.d. groups.

From Fig. 3 it can be seen that the ova fall into two distinct groups. Group 'a' is the stock of undifferentiated ova that are present in the ovary throughout the year; group 'b' is completely separated from 'a' and represents the stock of ova that will ripen and be spawned. There is no evidence of any secondary modes of differentiated ova. Hickling & Rutenberg (1936) and Prabhu (1956) have stated that the presence of such a single well defined group of mature ova, fully differentiated from the immature stock indicates a short and definite spawning period for the particular species. It is, therefore, quite likely that Tor Mahseer spawns once a year during a short spawning period. Supporting evidence is obtained from the seasonal changes in the gonads, and the availability of spawners only during a definite period.

Spawning

In order to determine the spawning season of *Tor tor,* the monthly percentage of females in different stages of maturity were determined. The immature fishes were not considered for this purpose. It could be seen that the fishes in developing stage were maximum in the samples obtained during October to February every year. Stage III fishes were first encountered in February and the maturing specimens (Stage III and IV), predominant during April-May, occur till July. Mature (Stage V) females started appearing in May and gradually in-

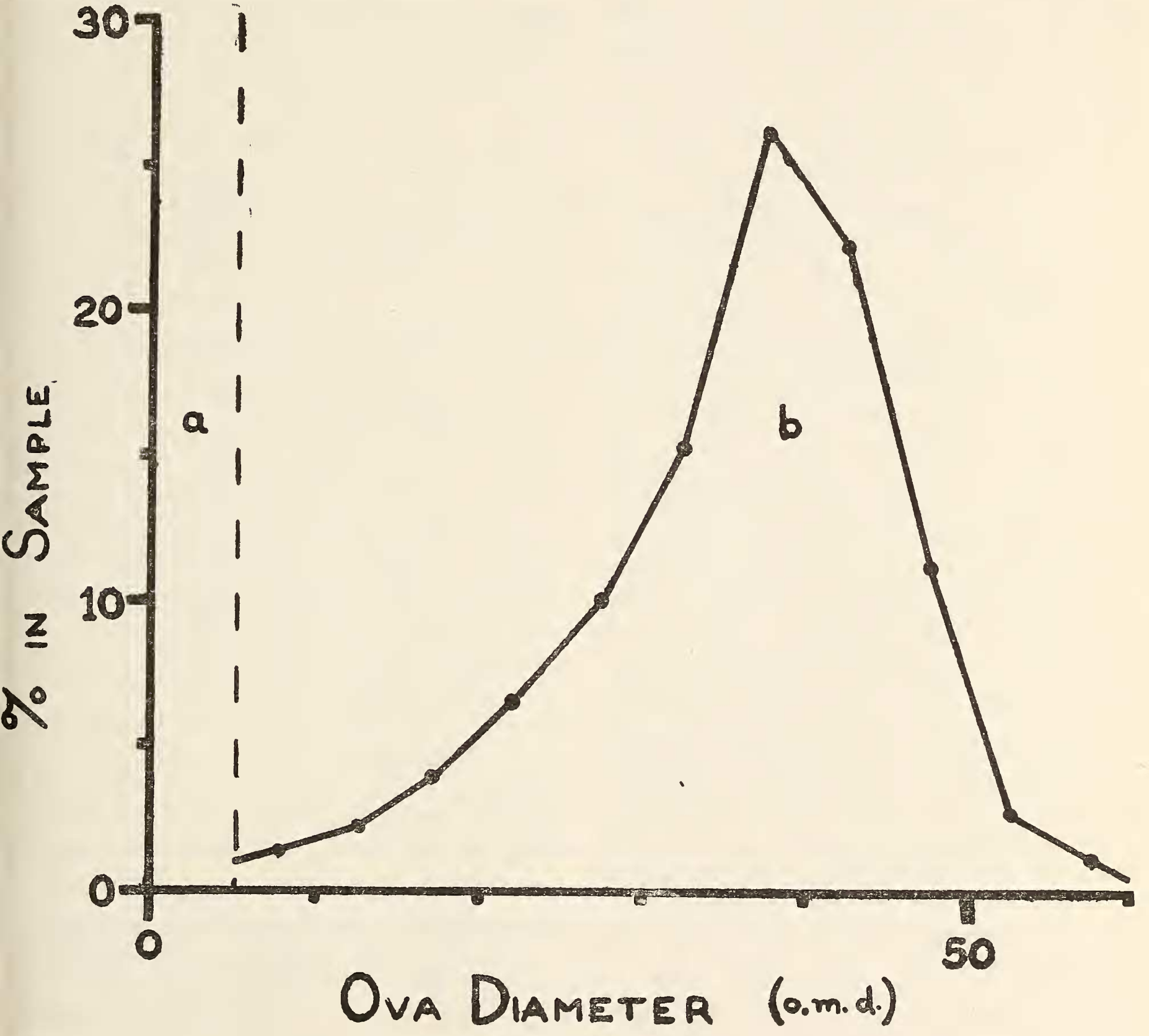

Fig. 3. Frequency distribution of ova in Tor Mahseer.

creased in proportions from June onwards. The majority of the females during July-September were mature or ripe, with its peak in August. The spent females first appeared in August and were recorded till October. The resorbing or spent recovering stages were occasionally observed during November and December.

Amongst the males also, only the earliest stages were found during October to February. The maturing specimens started appearing from March onwards and, during July-September the majority were in ripe or oozing condition. Spent males were observed in large numbers in September-October.

The Gonado-Somatic Index (gonad weight as % of body weight) also exhibits a similar cycle of seasonal changes. Fig. IV depicts monthly mean values of index for females and males separately. It could be seen that in the females the index values were very low during January-February. The values gradually increase in March, commencing a sharp rise in April to its peak in August. The sharp ascending limb of the curve occurred due to ripe females. This rise is followed by a decline in September due to spawning, reaching its lowest level in October represented by specimens mostly in spent or resting condition. A nominal increase in the index values in seen in November-December due to spent-recovering specimens.

The seasonal fluctuations of gonado-somatic index in the males was less marked, but showed a similar trend. There was the gradual increase in index values from April onwards, the index was high in July, reached its peak in August and then declined in September as there were a large number of spent males in the samples.

It can, therefore, be inferred from the monthly changes in the gonads that *Tor tor* breeds only once a year during a breeding season that extends from July to September, with its peak in August. Young fry collected only during August-September in large numbers further confirm it.

Discussion

Day (1873), Beavan (1877), Nevill (1915) and Sken-Dhu (1918) found that Mahseers breed several times in a year. Thomas (1897) recorded that they breed during the post-monsoon month and lay eggs in batches. Hora & Mukerjee (1936) and Hora (1939, 1940) observed that *Barbus* (*tor*) *putitora, Barbus*(*tor*) *tor* and *Barbus* (*tor*) *mosal* breed sometimes in August-September in the Himalayan rivers. Hora & Misra (1938) opined that *B.* (*tor*) *khudree* breed in August-September in Deolali hills. MacDonald (1948) states: "the putitor Mahseer is said to spawn three times in a year. In the Punjab, the three spawning seasons are (1) Jan.-Feb. (2) May-June and (3) July-September." Nazir Ahmed (1948) observed the breeding season of Assam Mahseer, *B.* (*Lissochilus*) *hexagonolepis* extending from April October with peak in August-September, whereas David (1953) dealing with Mahanadi Mahseer, *B.* (*tor*) *mosal mahanadicus* stated, "the breeding takes place only during the post monsoon period between October and November". He also found that in *B.* (*tor*) *khudree* and *B.* (*tor*) *musallah* spawning takes place in November in the cauvery system. Qasim and Qayyum (1961) reporting on *B.* (*tor*) *putitora* from Aligarh stated, "the species may spawn several times over a greater part of the year". Karamchandani observed that breeding season of *Tor-tor,* from Narmada river commences in July-August and continues upto December. Recently Kulkarni (1970) observed a fortnight or two between late July and early August as the peak breeeding season of *Tor khudree* in lakes near Poona.

Mahseers, therefore, appear to have a varied breeding seasons and according to many workers the spawning is prolonged even upto December. During the present investigation also a few large females in the maturing stages have been captured during November and December. Since it has been observed that the large specimens generally spawn earlier in the season, these might be the spent-recovered individuals and though it may lead one to think that these maturing females may mature and spawn soon it need not necessarily follow. Jones (1946) says "Fertilisable eggs in the ovary and presence of developing embryos and young fry in the waters inhabited by the fishes alone should, as far as possible, be taken as the proper criterion for judging the exact breeding period." Although the intensive sexual activity of carps and their capture with comparative case is well

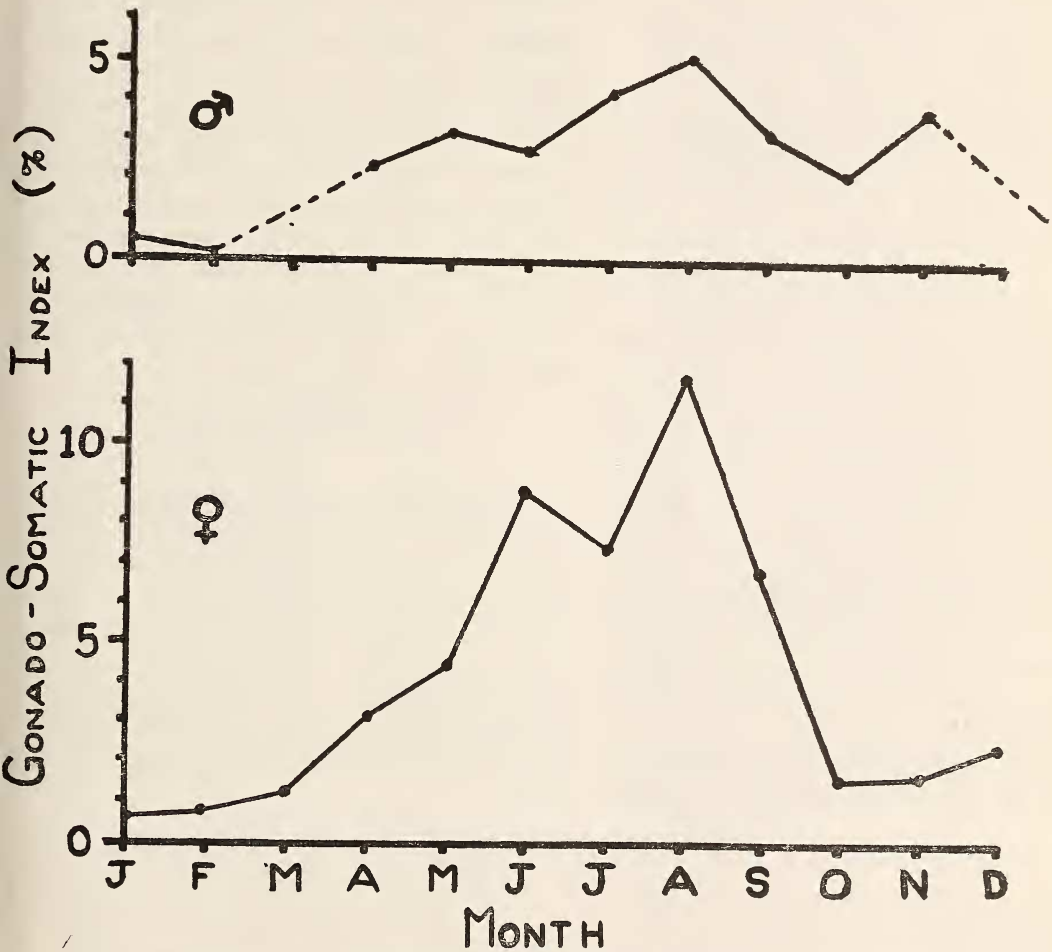

Fig. 4. The gonado-somatic index of males and females during different months.

known, no ripe males or females have been captured during October to March. Young fry are also altogether wanting during November to June. Hence the occurrence of a few maturing females during Nov.-Dec. may be better treated as exceptional and the possibility of breeding from October until the initial rains in June-July is altogether excluded. From all available evidence, it is clearly established that *Tor tor* spawns only once a year during July to September, with its peak in August.

Factors affecting spawning

In Indian Major carps, flood waters caused by rainfall or artificial means capable of inundating shallow areas are essential to induce spawning, Alukunhi & Rao (1951); Khanna (1958). Temperature is the other factor which has been found to affect the spawning of fishes Khan (1945); Das & Das Gupta (1945). The Mahseer prefers clean water and its migratory habits for breeding purposes are well known, Codrington (1946). In the Punjab, Mahseer is reported to spawn first in winter, secondly in May-June when the snow melts and rivers are swollen and thirdly from July to September when the rivers are flooded with the monsoon rains MacDonald (1948). David (1953) stated. "It would thus appear that optimum conditions for breeding are reached when the temperature is agreeable.... as in the relatively cooler waters of the Deccan plateau in the winter months."

The above observations strongly suggest that the flood of clear water accompanied by drop in temperature is the essential prerequisite for spawning of Mahseers. In the study area, the only significant rains occur with the south-west monsoon which may commence as early as late June and usually lasts upto September. After saturation and flushing by the initial rains the streams get flooded, low lying areas inundated, flow of clear water is made available and the temperature is lowered. But the exact timing of these optimum conditions for spawning is variable, because the rains are often erratic. The preceding observations on the monthly changes in the gonads, ova-diameter frequencies and the conditions of the maturity of the population demonstrate that the gonads in *Tor tor* are specifically adopted to cope with much variability and the availability of mature fishes during July-September ensures that there will always be some ready to spawn as soon as the optimum conditions prevail. As these conditions are likely to be best available in the later part of the rains only, the peak spawning is found to occur in August.

Acknowledgements

I am indebted to Dr M. M. Doshi, Director of Animal Husbandry and Fisheries, for his guidance, interest in the work and facilities offered for the same. Sincere thanks are due to Mr R. A. Wells, American Peace Corp Volunteer, for his ready help in the computations. I am also grateful to the staff of Fisheries Laboratory, Udaipur for the co-operation and assistance given throughout the course of this work.

References

AHMED, NAZIR (1948): On the spawning habits and early development of the Copper Mahseer *Barbus* (*Lissochilus*) *haxagonolepis* McClelland. *Proc. Nat. Inst. Sci. India, 14*:21-28.

ALIKUNHI, K. H. & RAO, S. N. (1951): On the bionomics, development and growth of a Cauvery carp, *Labeo kontius* Jerdon. *Rec. Ind. Mus. 49*:157-174.

BEAVAN, R. (1877): Handbook of fresh water fishes of India.

BENNET, GEORGE W. (1962): Management of artificial lakes and ponds. Reinhold Publishing Corporation, New York.

CLARK, F. N. (1934): Maturity of the Californea Sardine (*Sardinops coerula*) determined by ova diameter measurements. *Calif. Div. Fish and Game Fish Bull. 42*:1-49.

CODRINGTON, K. DE B. (1946): Notes on the Indian Mahseers. *J. Bombay nat. Hist. Soc. 46*:336-344.

DAS, K. N. & DAS GUPTA (1945): Breeding of the principal carps in Bengal. Symposium on the factors influencing the spawning of Indian carps. *Proc. Nat. Inst. Sci. India. 11*:324-327.

DAVID, A. (1953): Notes on the bionomics and some early stage of the Mahanadi Mahseer. *Jour. Asia. Soc. Sci. 19*(2):197-209.

DAY, F. (1873): Report of fresh water fish and fisheries of India and Burma.

DHAWN, S. (1969): Fish Fauna of Udaipur lakes. *J. Bombay nat. Hist. Soc. 66*:190-194.

FISHER, R. A. (1958): Statistical methods for research workers. Oliver and Boyd Ltd., Edinburgh.

HICKLING, C. F. & RUTENBERG, E. (1936): The ovary as an indicator of spawning period of fishes. *J. Mar. Biol. Ass. U.K. 21*:311-317.

HOLT, S. J. (1962): The Application of comparative population studies of Fisheries biology—an exploration. The exploration of Natural Animal Populations. pp. 51-71. Ed. by E. D. Le Cren and M. W. Holdgate. Blackwell Sci. Pub., Oxford.

HORA, S. L. (1939): The Game fishes of India VIII. The Mahseer or the large scaled barbels of India. *J. Bombay nat. Hist. Soc. 41*:272-285.

———— (1940): The Game Fishes of India IX. ibid. *41*:518-525.

———— & MISRA, K. S. (1938): Fish of Deolali, Part III. ibid. *40*:20-38.

———— & MUKERJEE, D. D. (1936): Fishes of eastern Doons, U.P. *Rec. Ind. Mus. 38*:139-142.

JONES, S. (1946): Breeding and development of Indian Fresh Water and Brackish water fishes. Part I. *J. Bombay nat. Hist. Soc. 46*:317-335.

KHAN, HAMID (1945): Observations on the spawning behaviour of carps in the Punjab. In the symposium on the factors influencing the spawning of Indian carps. *Proc. Nat. Inst. Sci. India. 11*:324-327.

KHANNA, D. V. (1958): Observations on the spawning of the Major carps at a fish farm in the Punjab. *Ind. Jour. Fish. 5*:282-290.

KULKARNI, C. V. (1970): Spawning habits, eggs and early development of Deccan Mahseer *Tor khudree* (Sykes). *J. Bombay nat. Hist. Soc. 67*:510-521.

MACDONALD, A. ST. J. (1948): Circumventing the Mahseer and other sporting fish of India and Burma. Bombay Natural History Society, Bombay.

NEVILL, C. A. (1915): The breeding habits of the Mahseer (*Barbus tor*). *J. Bombay nat. Hist. Soc. 24*(4):838.839.

PRABHU, M. S. (1956): Maturation of the intra-ovarian eggs and spawning periodicities in some fishes. *Ind. Jour. Fish. 3*(1):59-90.

QASIM, S. Z. & QAYYUM, A. (1961): Spawning frequencies and breeding seasons of some fresh water with special reference to those occurring in the plains of Northern India, ibid. *8*(1):24-43.

SIMPSON, A. C. (1951): The fecundity of the plaice. *Fishery Invest. Lond. Ser. II, 17*(5).

SKEN-DHU (1918): The Angler in Northern India. Allahabad.

THOMAS, H. S. (1897): The rod in India. London.

WOOD, H. (1930): Scottish herring shoals. Pre-spawning and spawning movements. *Scotland J. Fish. 3*(1):59-90.